PORTABLE CLOCK ANALYSES

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ABSTRACT

The portable clock remains the most frequently used means of time dissemination and of calibration of precise clocks to the U.S. Naval Observatory Master Clock (USNO MC). Because of this, portable clock trips and the factors that influence the confidence placed in the measurements obtained must be understood. In this paper, the general philosophy of trips and some of the error factors that can occur are discussed. The stability of individual USNO portable clocks is determined by analysis of pre- and post-trip measurements obtained through the USNO data Acquisition and Control System. Using these data, this paper explores their historical accuracy and determines error budgets. The feasibility of determining a statistical "reliability factor" based on the pre- and post-trip readings of an individual clock is also examined. From these studies the dependability and reliability of portable clock trips as a whole, may be concluded.

(ABSTRACT ONLY)

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QUESTIONS AND ANSWERS

MR. SAM WARD, Jet Propulsion Laboratory

It's not necessarily a question, but more a statement. Since the pre and post measurements were made in the same environment, one would expect that a stable cesium would get the same answers.

The, how much time offset you can expect when you return is a function of how long it was in some environment, especially magnetic that caused it to, change its rate. And longer trips the measurements, the guesses that we have made is what the longest trip that would be practical before that you got diminishing returns (at one time, I think, we thought it was seven, ten days).

But there's really no relationship between the length of the trip away and the behavior of the clock.

MS. NEVILLE:

And the behavior of the--

MR. WARD:

And the behavior, except for the performance of that individual clock.

MS. NEVILLE:

Right. Which of course, this may be another factor as well.

DR. WINKLER:

I would like to make a comment here which may be useful, to illustrate the direction of these efforts. We are making a major effort to improve the accuracy of portable clock time transfers and the estimate of errors that is an extremely important function. The clock that is very expensive, and one of the results which you see are these searchers, which, I must say are excellent to find an objective measure.

Now, such an objective measure as Ms. Neville has shown, can be composed, must be composed of several factors. One of them is documentation. It is utterly necessary, and yet it is more difficult than anyone would think it is to extract from our portable clock carriers the necessary information.

It's a constant struggle. It's, well there are many reasons why that is difficult, but it is absoultely essential.

I think the lesson to be learned from the data shown until now (and I hope that efforts like this will continue) is that a portable clock trip has about the same limitations as any enterprise. There has to be some judgement, how much money you want to spend, and how much is really required.

Well, we do make that selection in some of our clock trips. We send the very best clock which we have. Incidentally your clock 1452 or 3, I think, is older than three years. We do not have any clock which is younger than that at the moment because last year we had absolutely zero dollars available for clock purchases.

MR. MCCULLOUGH, Oceanographic

It, would seem that since the oscillators are banging around in the magnetic fields, the temperature fields and so forth, have those functions been monitored to find out what's going on on a trip, and secondly, have those function been simulated in the laboratory to see what kind of parametric changes to expect?

MS. NEVILLE:

Dr. Winkler can answer that.

DR. WINKLER:

Over the years we have made extensive tests. In fact, one of the best tests ever made was in conjunction with Professor Alley's experiments on a P-3, portable clock (in fact, a very good one) was mounted without protection in the same aircraft, and measured continuously against the clock set. The time base, which was available on that clock set was better than one nanosecond.

And, the greatest effect was during takeoff and landing. You can see that this produced a shock, which produces an almost instantaneous phase offset. The longer lasting frequency changes, or, the residual frequency changes almost have to be considered as partly to be expected. If you use a clock which, for instance the regular 5061 would have an Allan variance for a one day interval of about one part 10 to the 13th. So it's to be expected that your rate will vary by about a part in 10^{13} after a week or so.

What one has to separate is the systematic effects. And coming back to a question of tests, for instance a good test for a portable clock is to turn it upside down in the laboratory. And measure the frequency shifts after one day. We discussed that about 4 years ago, here in the same conference. At that time, I think, somebody I forgot who, brought my attention to the effect in this case is due to the temperature change in the clock. When you do that the temperature gradient will be inverted. There

is one thing frequency shift is a good indication how the clock will perform during the trip when it is exposed to temperature variations. Magnetic fields, correct it should be measured. But all of this goes back to the need to document what's happening. There are some clock trips which are carried out beautifully without any mishap whatsoever. The clock is protected, temperature changes are modest, you don't go from a hot exterior to an air-conditioned interior and so on.

So, in this case I think a greater weight has to be assigned. That is exactly what the cesium is trying to accomplish through assigned weights on the basis of a documented history of the portable clock.

Thank you.